The management of water shortage by water safety plans

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by

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The management of water shortage by water safety plans

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Table of Contents

List of Figures

List of Tables

SUMMARY

Introduction

One of the primary requirements for the protection of public health within a community is an adequate supply of safe drinking-water. That is, the supply must provide enough water of satisfactory quality.

Water shortage results when a community's demand for water outstrips the water available to its water supply. The global drivers of climate and demographic change are likely to increase the probability that water supplies will face water shortage through decreasing water availability[1] (through drought) and increasing the demand for water (more people consuming).

One of the tools with which water suppliers manage public health risk associated with water supplies is their water safety plans. This study was undertaken to assess the extent to which water safety plans manage the risk of water shortage.

Method

Twenty water safety plans were obtained from territorial authority water suppliers. The criteria for selection were that they had an approved water safety plan and had either experienced drought or were experiencing (or expecting) population growth. Thirteen of the supplies were large, one medium, four minor, one small and one a neighbourhood supply. Each water safety plan was reviewed and information relating to the risk management of water shortage was extracted from the plan. Water safety plans commonly referenced others document that contained further detail about management measures. These documents were not accessed as they were outside the scope of the project brief.

Water safety plan information

Four generic situations were identified that might lead to water shortage: emergencies arising from malfunctions in the system; drought; the existing on-going routine demand for water; and future increases in demand for water. These situations present the risk of water shortage at different durations and over different timescales. The measures necessary for managing the risk depend on the situation.

The management measures contained in each water safety plan were reviewed and a set of generic measures for managing water availability and water demand were identified to help in assessing how well each situation was managed by each water safety plan.

The sources of information used in preparing the water safety plan were identified. These were of two types: referenced documents (such as asset management plans, and long term plans), and observations, measurements and analyses. The identification of these sources is to provide guidance for others preparing water safety plans.

The relationships between the water safety plans and the external documents were not made clear in most water safety plans. However, information from one water

[1] Decreased availability could conceivably arise from deteriorating quality through climate change, because of heavy rain, for instance. Episodes of poor source quality could limit the periods when abstraction is possible and consequently the quantity of water available.

safety plan showed that there are links between the water safety plan and the asset management plan, and the long-term plan. The water safety plan assesses the public health risks to be managed, and what supply improvements are required to manage that risk. Supply improvements are implemented through and asset management plan.

The roles that contingency plans and the improvement schedule in water safety plans play were examined because these are the action-orientated parts of the water safety plan that translate the risk information in the plan to external action. Contingency plans are designed to manage relatively brief events, emergency situations and drought. The improvement schedule puts in place missing management measures, and may benefit both short–term and on-going situations.

Key findings from assessment of the water safety plan information

a. Water safety plans are the appropriate document for setting out how to prepare for and manage the public health risk of water shortage arising from brief emergency situations, drought and existing routine water demand. The preparation and implementation of approved water safety plans is a statutory requirement under the Health Act 1956.

b. In general, documents external to water safety plans and having a more distant planning horizon, such as asset management plans, and territorial authority long-term plans, appear to be used for future water demand planning, not water safety plans. As a result, how well future risk is being managed could not be assessed in the study.

c. Almost all the water supplies (participating in the study) presently have implemented measures capable of managing the risk of water shortage arising from drought.

d. Only about a third of water supplies have measures in place that are expected to robustly manage the risk of water shortage arising from routine water demand.

e. Three quarters of the water supplies have measures in place that although less robust will still contribute to managing the routine risk of water shortage.

The relatively small number of water safety plans examined, the selection criteria for the participating supplies, and restricting the study to considering only water safety plans, limit the confidence with which the conclusions from the report can be extrapolated to water safety plans in general throughout New Zealand.

Three issues became apparent through the study:

a. The Ministry of Health's guidance documents for water safety plan preparation have an emphasis on water quality, which may influence the extent to which continuity of supply is addressed in water safety plans

b. Water suppliers and drinking-water assessors would probably benefit from guidance on how external documents should be used in conjunction with water safety plans, and in particular, how water safety plans can show whether referenced external documents are adequately managing risk

c. Guides to the preparation of water safety plans are silent on how far into the future risks should be managed, and guidance on this would be helpful to

water suppliers and drinking-water assessors in agreeing on what water safety plans should contain.

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1 INTRODUCTION

One of the primary requirements for the protection of public health within a community is an adequate supply of safe drinking-water, that is, the supply must provide enough water of satisfactory quality. The water should also be palatable. Water with unsatisfactory aesthetic properties, apart from giving rise to complaints, may also lead to consumers seeking other, aesthetically better but unsafe, water sources.

The *Drinking-water Standards for New Zealand 2005 (Revised 2008)* (the Standards) sets out the requirements for a safe and palatable water (termed wholesome). The focus of the standards is on the quality of drinking-water rather than ensuring that a supply is always capable of providing sufficient water to meet demand. It is the drinking water section within the Health Act 1956 (the Act) (s 69S) that requires water suppliers to provide an adequate supply of water, that is, to avoid a water shortage.

Water shortage results when a community's **demand for water** outstrips the ability of a water supply to provide enough water to meet that demand. The two factors, sometimes occurring simultaneously, which can lead to water shortage and which are of primary interest in this report are: decreased **availability of water**[2] from the source and an increased demand for it. It is also possible that infrastructural limitations, such as a treatment plant with insufficient capacity, may hinder the water supplier in meeting the water demand.

Climate projections indicate that parts of New Zealand are likely to experience less rain during some seasons and that droughts will be become more frequent and/or severe droughts (MfE 2008). Consequently, for some parts of the country, water suppliers are likely to experience periods when the availability of source water decreases. At these times the demand for water will increase because of the dry weather (through such activities are irrigation, both domestic and agricultural). Population growth or industrial, commercial or agricultural development, will further heighten the demand for water in some areas.

ESR has prepared a report for the Ministry of Health that assessed how demographic changes may affect water supplies (Nokes 2013). That study included the effects of increased water demand. It examined the long-term plans of local authorities for evidence of how the consequences of demographic change for water supplies would be managed. **Water safety plans** (formerly known as public health risk management plans) are another tool for managing the risk of water shortage.

The purpose of this report is to provide the Ministry with an assessment of the likely ability of water suppliers to meet increased water demand or manage decreased water availability. The assessment is to be made on the basis of water safety plan content.

[2] Decreased availability could conceivably arise from deteriorating quality through climate change, because of heavy rain, for instance. Episodes of poor source quality could limit the periods when abstraction is possible and consequently the quantity of water available.

Report structure

Section 1	Introduction to the study
Section 2	Explanation of how the information required for the study was obtained
Section 3	Summaries and discussion of the information contained in the water safety plans, and categorisation of the measures for managing the risk of water shortage to help.
Section 4	Assessment of how well water shortage is being managed on the basis of the information in the water safety plans based on the information contained in Section 3
Section 5	Brief discussions on three issues that became apparent as the result of the study
Section 6	Conclusion

Terminology

The Ministry of Health's publication, *How to Prepare and Develop Public health Risk Management Plans for Drinking-Water Supplies* (MoH 2001) provides terminology for the components of water safety plans. The terminology used in this guidance document, though not universally recognised, is still found in many water safety plans. Consequently, it is used in this report to provide a common framework for classifying the information contained in the plans.

2 METHOD

2.1 Overview

This study is based on the contents of water safety plans obtained from a selection of water suppliers. The majority of water safety plans are from large supplies. The content of each plan relevant to the management of water shortage was reviewed, and this information is used as the basis for the preparation of the report. While water suppliers may use other documents, such as asset management plans and long-term plans in planning to manage water shortage in the longer term, the scope of this project is restricted to consideration of water safety plans.

2.2 Selection of supplies for the study and procurement of water safety plans

The agreed scope of the study required the survey of water safety plans from 20 territorial authority water supplies. Public health units were contacted by email, which outlined the study, provided the criteria for water supply inclusion, and sought an appropriate contact for four supplies in their district to approach for a copy of their plan. The inclusion criteria for the study were that the plan was to be approved, and that the water supply had experienced water shortage problems in the past, or that its water demand was increasing, or expected to increase. The project brief required the inclusion of Wellington and Auckland.

Requests for a copy of their water safety plan were made to water suppliers once contact information was received from the public health units. All suppliers contacted were prepared to help, although difficulties were experienced in obtaining plans from some suppliers.

Plans, or partial plans, were obtained for 13 large supplies, one medium supply, four minor supplies, one small supply and a neighbourhood supply[3]. Supplies were assigned an identifying letter (A-T) to preserve their anonymity. Basic information about the anonymised supplies is presented in Table 1.

A full water safety plan was not obtained from Supply S. The water supplier provided those sections of the risk table that they considered apply to the study, and noted that other documents were also used in the management of water shortage and that these might be more useful.

Only the water safety plan for the reticulation of Supply T was obtained, although some risk management information concerning the source and treatment was included in this plan.

The incomplete nature of the water safety plans from Supplies S and T may provide a distorted view of their management of water shortage, particularly for Supply S.

[3] Supply sizes are defined by s.69G of the Health Act 1956.

Table 1 Outline of the character of the water supplies contributing to this study

Supply Identifier	Supply Size Category	Type of source	Maximum volume of water available daily per person[1] (L)
A	Large	River, bores	640
B	Large	Rivers, dams	940
C	Large	Rivers (direct abstraction and infiltration gallery)	1,270
D	Minor	River	3,440
E	Minor	Bores	1,740
F	Minor	Rivers	1,690
G	Medium	River (infiltration gallery)	3,080
H	Large	Lake, river	1,180
I	Minor	Bores (infiltration gallery)	870
J	Large	Bores	690
K	Large	River	570
L	Large	River, stream, dam, springs	620
M	Small	Bores	1,610
N	Large	River	840
O	Large	Lake	2,500
P	Large	Stream	1,500
Q	Neighbourhood	Lake	2,530
R	Large	River	1,420
S	Large	Lakes, river, bores	500
T	Large	River/lake	1,510

[1] Calculated from the 'Volume Capability' data from the 2014 edition of the *Register of Drinking Water Suppliers for New* Zealand[4] and the population for the supply reported in the *Annual Report on Drinking-water Quality 2012-2013*[5]. These figures are not a measure of per capita consumption. They provide an indication of the volume of water **potentially** available per person

[4] Available at: http://www.esr.cri.nz/competencies/water/Pages/RegisterofDrinkingWaterSuppliersforNZ.aspx (accessed 9 July 2014)

[5] Available at: http://www.health.govt.nz/publication/annual-report-drinking-water-quality-2012-2013 (accessed 9 July 2014)

2.3 Review of the water safety plans

The risk table, contingency plans and improvement schedule of each of the water safety plans received were scanned for items relevant to the management of water shortage. This information was paraphrased for conciseness, and to preserve anonymity, and is tabulated in Appendix 1.

The findings and discussion focus on water shortage resulting from problems of water availability and demand. Water safety plans identify other reasons for water shortage, such as the breakdown of pumps. Information associated with these causes is not within the scope of the study, and although measures to manage these situations are identified for the sake of completeness, they are not discussed in the report.

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3 FINDINGS AND DISCUSSION

3.1 Introduction

This section presents and discusses the information found in the water safety plans. As part of the introduction to this section, the different situations in which water shortage has to be managed are considered. This supports the rest of the discussion in the section and the assessment of Section 4.

The bulk of the section discusses the measures that have been identified in the water safety plans for managing water shortage. The measures are categorised to help in understanding how they contribute to managing water shortage.

Two important components of water safety plans, because they are action orientated, are the contingency plans and improvement schedule. Discussion of their role in managing water shortage follows the broader examination of management measures.

To help others in planning for water shortage, the last part of the section looks at which sources of information were used in preparing the plans. It also identifies observations, measurements and analyses identified in the plans that could help in planning for managing water shortage.

3.1.1 Risk situations being managed

For the purposes of this report, the risk of water shortage is considered to arise in four situations, as shown in Table 2.

Complete management of water shortage risk, including that arising in the more distant future, requires the risk associated with each of these situations to be managed. The measures necessary for managing the risk depend on the situation.

Table 2 Situations in which water shortage may arise and has to be managed

Situation being managed	Duration	Description of what is being managed
Emergency	Very short term	Emergency situations, such as an abstraction pump malfunction, in which water shortage (or even absence) may last hours or a few days at most
Drought	Short term	Periods during which availability of source water may drop for weeks or months.
Existing routine demand	On-going	The continuing need to balance routine water demand (including fluctuations) and water availability at present and in the near future.
Projected future demand	On-going	The demand for water in the more distant future.

Drought duration is classified as short term, but both the frequency and duration of drought in the future may increase. Under these circumstances, the measures presently used to manage the routine situation, may also become appropriate for managing drought. For example, water restrictions being applied on a regular basis for extended periods may become unpalatable or ineffective, and the development of

a new source to provide the capacity needed during drought would be a more suitable measure.

3.2 The content of water safety plans

The Ministry of Health identified the importance of shifting water supply management from reliance on monitoring to the use risk management techniques in the early years of this millennium. Consequently, although the legislative basis for the use of water safety plans was not introduced into the Act until 2007 by the Health (Drinking Water) Amendment Act 2007, initiatives to encourage this transition started in 2001.

In that year, the Ministry of Health published tools to assist water suppliers in preparing water safety plans[6]. The Ministry's publications suggested that a plan needed to include a table identifying possible risks and how those risks would be managed, as well as contingency plans and an improvement schedule. The improvement schedule was to identify what needed to be done to address risks not already addressed. It also needed to include the relative importance of each improvement, the timetable for implementing the improvements and who had responsibility for making them.

These publications were guidelines only. The Act now specifies what components of a water safety plan are legal requirements (s 69Z(2)(a)). These requirements include the need to identify public health risks associated with water supplies, the mechanisms by which these risks are to be managed and a timetable for managing the identified risks. Although not explicitly identified in the Act, these mechanisms should include **preventive measures**, **corrective actions** and **contingency plans**, as they are termed in the Ministry of Health's framework.

Although the terminology varied between water safety plans most plans contained components that could be considered equivalent to these three components in the Ministry's framework. The relevant detailed risk information culled from these components of each water safety plan is presented in Appendix 1.

3.3 Water shortage management information from water safety plans

3.3.1 Introduction

Section 3.3 examines the information contained in the surveyed water safety plans that is relevant to the management of water demand and water availability. The measures recorded in the plans are grouped into generic categories to help identify which of the situations in Table 2 each measure addresses.

3.3.2 Generic management measures

Grouping the measures contained in the water safety plans to manage water shortage is done in two stages.

Table 3 lists the measures (paraphrased) for managing the risk of water shortage from each water safety plan. Each measure is assigned to one of three columns. Two columns contain measures intended to manage the risks associated with the broad areas of water availability and water demand. Measures in these two columns

[6] Termed public health risk management plans at that time

have already been, or are being, taken. A third column lists measures yet to be implemented in the supply. While some of these are contained in improvement schedules, several plans list some future actions as a subcategory of preventive measure. Both types of measure have been included in the "Future improvements" column of the table. Measures in "Future improvements" may also appear in either of the first two columns.

Table 3 Listing of supplies and summaries of how each addresses water availability and water demand, and what future measures are planned to address both concerns.

Letters in brackets denote the nature of the water shortage the measure addresses (see Table 2): E – Emergency; S – Short-term; R – existing Routine demand

Supply	Measures to address water availability	Measures to address water demand	Future improvements
A	• Supplementary source (S)	• Water restrictions (S) • Emergency demand management (E, S)	• Reduction in water use (R) • Investigate new source (R)
B	• Second treatment plant (R) • Actions related to resource consent (R)	• Water restrictions (S)	
C	• Tankered water (S) • Dual sources (R)		
D		• Management of large non-residential demand (S) • Loss management (R)	• Develop new source (R)
E	• Actions related to resource consent (R)	• Conservation measures (when shortage likely) (S)	
F	• Supplementary source (S) • Pre-treatment storage (R)	• Demand management (when shortage likely) (S) • Loss management (R)	• Investigate new sources (R)
G	• Augment with neighbouring supplies (E) • Post-treatment storage (9 hours) (E) • Supplementary source (S)	• Water restrictions (S)	• Develop water restriction guidelines (S) • Investigate new sources (R) • Increase storage capacity (S)
H	• Actions related to resource consent (R)	• Water restrictions (S)	• Develop water demand management plan (S)
I		• Water restrictions (S) • Loss management (R)	• Develop new source (R) • Improvement of loss management programme (R)

Supply	Measures to address water availability	Measures to address water demand	Future improvements
J	• Address regional council water resource management policy (R)	• Water restrictions (S) • Loss management (R)	• Develop new source (R) • Supplement from neighbouring supply (S)
K	• Actions related to resource consent (R) • Flexibility of abstraction (S) • Tankered water (S)	• Water restrictions (S) • Conservation measures (when shortage likely) (S)	• Develop alternative source (S) • Actions related to resource consent (R)
L	• Alternative source (R) • Tankered water (S)	• Water restrictions (S)	• Develop new source (R) • Improve abstraction (R) • Construction new treatment plant (R) • Develop loss management programme (R)
M	• Multiple sources (R) • Actions related to resource consent (R) • Properties with on-site storage (R) • Tankered water (S)		• Develop new source (R) • Water restrictions (S) • Conservation measures (when shortage likely) (S) • Conservation measures (R)
N	• Post-treatment storage (24 hours) (E)	• Water restrictions (S) • Conservation and Demand Management Plan (R) • Drought Response Plan (S)	• Develop alternative source (R)
O	• “Unlimited” source (R)	• Water restrictions (S)	• Improve abstraction (R) • Loss management (R) • Emergency source in event of plant failure (E) • Demand management (R)

Supply	Measures to address water availability	Measures to address water demand	Future improvements
P		• Loss management (R) • Conservation measures (during high use periods) (S) • Management of large non-residential demand (S)	• Investigate additional abstraction from existing source (R?) • Investigate additional post treatment storage (E) • Investigate new source (R) • Loss management (R) • Review demand management (R)
Q	• Depth of abstraction (S) • Actions related to resource consents (R)	• Demand management (S)	• Investigate augmentation from neighbouring supply (S)
R	• Actions related to resource consents (R) • Post-treatment storage(E,S)	• Loss management (R) • Water restrictions (S) • Water conservation (S) • Public notices (E,S)	• New source (R) • Develop contingency plan (E, S) • Actions related to resource consents (R)
S	• Flexibility of abstraction (R)	• Drought management plan (S)	
T	• Multiple sources (R) • Forward planning to meet future demand (R) • Additional storage (E)	• Water conservation (R) • Water restrictions (S) • Model system capacity (R) • Demand projections for future demand (R) • Public notices (E,S)	• Infrastructure upgrade (R) • Investigate new source (R) • Asset development plan in asset management plan (R) • Investigate reasons for water demand (S) • Revise demand projections (R)

Table 4 takes the measures recorded in Table 3 and groups them into categories. A water safety plan does not require all of these measures to manage water shortage. The table presents the possible measures a water supplier may use for managing water shortage, depending on their circumstances, based on the information contained in the 20 water safety plans surveyed.

Measures not contained in Table 4 could also be helpful in managing water shortage. Appendix 2 offers a list compiled by the US Army Corps of Engineers (USACE 1994), to provide another view of possible management measures for drought. Many of these are not present in Table 4, although some may be contained in documents, such as demand management plans, referenced in the water safety plans.

Table 4 Categorised measures for managing water shortage

Measures to manage water shortage
Water availability
Increase the amount of water available
Develop new sources • Replace the existing source • Augment the existing source
Develop supplementary sources (to be brought online when the need arises)
Increase pre-treatment storage
Require on-site storage for (rural) properties
Provide tankered water
Increase treated storage
Increase the volume of water that may be abstracted
Address issues relating to consents/regulations • Liaise with the consent authority • Work with the consenting authority in water resource planning • Ensure there is input to the consenting process • Restrict takes by other users
Overcome infrastructure limitations
Improve ability to abstract water • Increase number of takes from source • Design abstraction to allow for drops in water level in source (surface and groundwater)
Increase treatment capacity
Water demand
Develop water demand management plans • Obtain projections of future demand • Model system capacity
Encourage water conservation • Develop education programmes
Ration or restrict water use • Make by-laws or regulation to permit control of water use
Draw up agreements with large industrial users to reduce demand or close down when water shortages become a concern.
Investigate, detect and repair leakage from the network

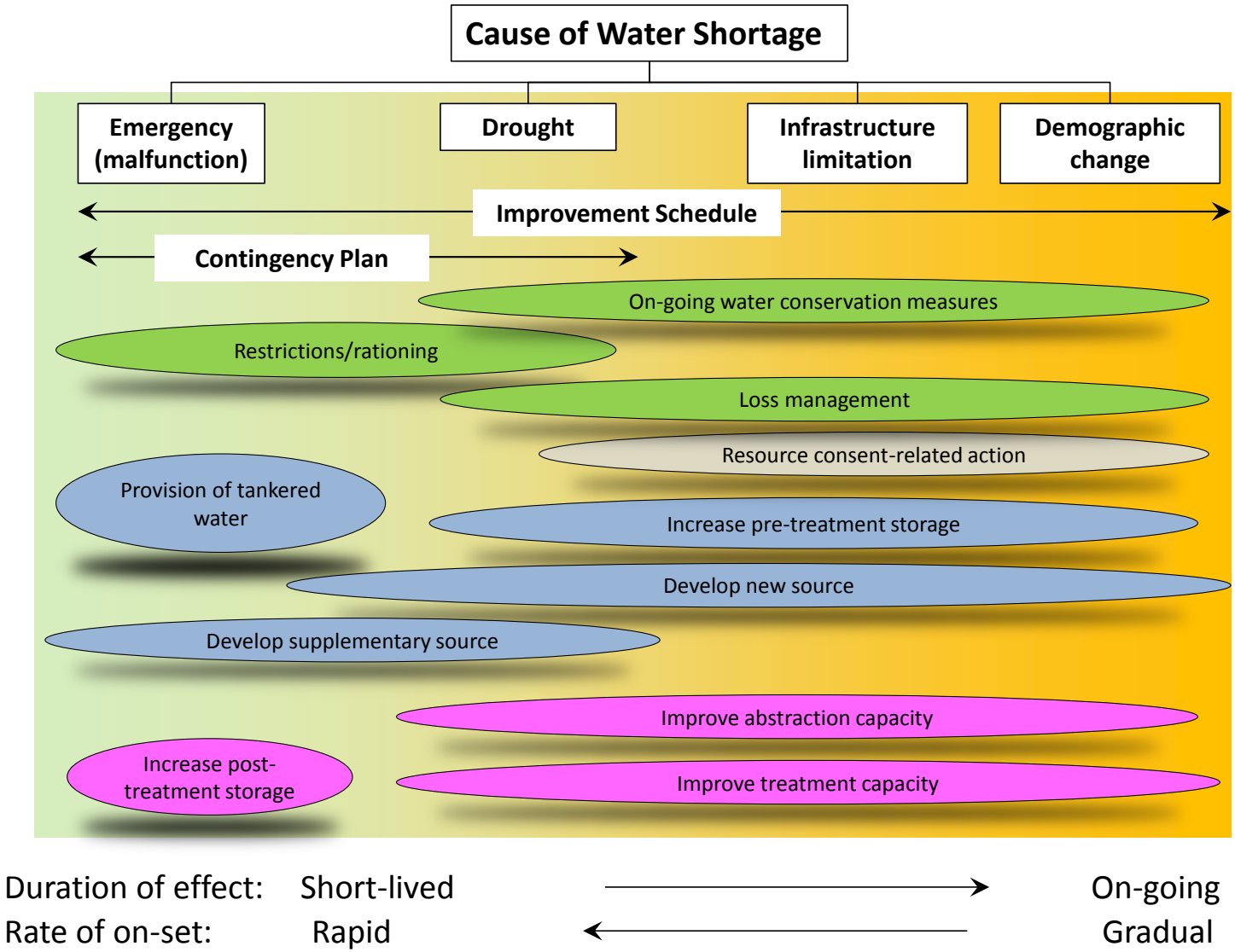

Figure 1 Depiction of how management measures relate to the timeframes of the causes of water shortage.

Figure 1 integrates information from Table 2 and Table 4 to show the timescales over which different measures are applicable[7]. It also shows the timescales over which contingency plans and improvement schedules operate.

The following two subsections discuss the information contained in Table 3 and Table 4.

3.3.2.1 Measures addressing water availability

Preventive measures are the steps that a water supplier can take to reduce the likelihood of an unwanted event. An example is ensuring that a stand-by chlorine cylinder is always available to reduce the likelihood of exhausting the on-site supply of chlorine. Preventive measures recorded in water safety plans generally identify measures that manage existing risks rather than ones that may arise in the more distant future. They may include measures already taken and desirable measures that have yet to be implemented, which strictly speaking should be included in the improvement schedule. They are included in the "Future improvements" column of Table 3.

The water supplier cannot prevent the meteorological conditions that lead to droughts or control their duration. Water safety plans have to manage water availability with this intrinsic limitation. While the direct cause of reduced water availability cannot be prevented, measures can be taken to limit the impact of drought. Water safety plans identify three classes of measure to manage the availability of water for supply.

a. Increase the amount of water available

   These measures are concerned with ensuring there is physically enough water available to abstract. Measures recorded within this class range from those providing an on-going supply of source water to measures that address short-term water shortage.

   The development of a new source, or sources, can be intended to **replace** an existing source because available quantity or quality, or both, make the existing source unsatisfactory. A new source may also **augment** the existing source, running in parallel with it. In both situations, the overall volume of water available is increased, which provides an on-going solution to managing the risk of shortage.

   Sources referred to as "supplementary" in water safety plans are switched on when there is a need during extended dry periods or short-term increased demand. They are not needed to meet routine demand. Whether they could be used continuously as an additional source is unclear from the water safety plans in which the term is used. For the purposes of classification, they are regarded as managing the problem of water availability in the short-term. They allow the supply to cope with dry periods provided they are not of extended duration and they are not of high frequency. The use of a supplementary source of lower quality or having a lower level treatment increases the risk to public health which should be addressed in the water safety plan. As the effects of climate change

[7] This is not the rate at which the measures can be implemented. It is the duration of the event they are best suited to manage. For example, increasing the amount of post treatment storage available may take months, but when completed this additional storage is still only going to be capable of managing water shortage arising from short duration events.

become more severe, drought may become more regarded as “routine” and new sources allowing continuous abstraction are more likely to be required.

Increasing the volume of pre-treatment storage available provides the capacity to store water during periods of plentiful rain for use during periods of scarcity. The adequacy of the measure for a particular supply will depend on such factors as the demand of the community being supplied, the volume of storage, and the relative duration of periods of plentiful rainfall and scarcity. The use of pre-treatment storage does come with potential quality problems, for example, there is an increased likelihood of cyanobacteria blooms during warmer weather.

In the broader sense, pre-treatment storage also includes on-site storage at the individual household level, which is noted as measure in at least one water safety plan. On-site storage can increase public health risk. This should be addressed in the water safety plan. It is also shifts the cost of managing water shortage from the water suppliers to the consumer.

Improved post-treatment storage is recorded as a measure to prevent water shortage in some water safety plans. However, the volumes of post-treatment storage that a water supplier can construct provide periods of only hours or days for which the demand of the supplied community can be met. Consequently, increased post-treatment storage is a measure for managing emergency situations (such as the need to close down the intake in the event of untreatable raw water quality, or intake blockage) only.

The last type of measure recorded in water safety plans for increasing the volume of water available for supply to the community is the use of water tankers. This is primarily identified in contingency plans. While it may be used as a measure to ensure a community receives sufficient water for survival for a period of days, again, it is an unsatisfactory means of managing the problem of water availability over a long period. Extended use of water tankers may also increase the public health risk because of the possibility of contamination during the water transfer steps or problems with maintaining the cleanliness of the tankers.

b. Increase the amount of water that is allowed to be abstracted

This class of measure aims to ensure that limitations on abstraction imposed by regulation do not hinder the water supplier’s ability to meet water demand.

The resource consent is the regulatory tool by which consenting authorities manage their water resources. Several water safety plans identify limitations imposed by resource consents as a possible threat to their ensuring an adequate supply of water. Table 4 outlines the types of action that have been recorded for avoiding water shortage arising from consent restrictions.

Some water suppliers record the need to be applying for consents well in advance of the expiry of their existing consent. There appears to be a concern that the consenting authority could potentially limit their take to a point at which their supply’s demand for water could not be met. Consenting authorities have obligations under the Resource Management Act 1991. These obligations often have an environmental or cultural imperative which may at times conflict with the needs of water suppliers. Section 69T of the Health Act 1956 identifies actions that a water supplier must take if they consider their ability to maintain an adequate supply of water is, or may be, at risk. The application of s 69T has yet to be tested in court.

Provided the future water requirements of a community have been accurately assessed when the consent is sought, this action should ensure that the water supplier is allowed to abstract water sufficient for its needs two or three decades into the future. The water supplier needs to be aware that the consenting authority is likely to take excessive per capita consumption into account when a consent is sought or renewed. Even though the renewal of a consent may be several decades away, water safety plans note the need for being actively involved in hearings that may affect the availability of water from their supply's source.

c. Overcome infrastructure limitations

Infrastructure limitations noted in water safety plans are concerned with the abstraction of the water or the capacity for the existing treatment plant to process enough water to meet the demand. Physical (as opposed to regulatory) measures to allow more water to be abstracted from a source or to treat larger volumes of water potentially avoid these points in the water supply train restricting water availability in the long-term. The success of these measures depends on there being sufficient source water available for abstraction and treatment.

3.3.2.2 Measures addressing water demand

The general term "water demand management" appears widely in water safety plans, sometimes referring to a plan outside the water safety plan. The term is usually undefined, and could include a broad range of measures, from water restrictions, to longer-term water conservation measures, and water loss (leaks) management.

Per capita water consumption in New Zealand is high in some communities[8]. Managing this demand is likely to be a key long-term strategy for avoiding water shortage.

The term "water restrictions" is generally understood to include measures such as those limiting the use of garden watering. Water restrictions are a response to a developing situation in which water availability is decreasing and there is a need to reduce consumption to avoid serious difficulty in meeting demand. The measure is a short-term response; it is not intended to provide on-going management of trends in water demand or water availability. Further, it is a compulsory measure, a point noted in some water safety plans by reference to the by-law under which the restrictions are implemented.

Water usage can be reduced through financial control, such as metering in combination with pricing strategies. Metering is noted in some of the water safety plans surveyed, but pricing strategies are not. This measure may be contained in an external document referenced in the water safety plan.

While the water used by residences within a community frequently constitutes a large percentage of water consumption non-residential consumers may also account

[8] For example, the water safety plans of Greymouth and Queenstown show per capita consumption of 750 and 580 L/person/day, compared with 2010 figures of 475, 310, 164, 148 and 121 L/person/day for the United States, Canada, France, Great Britain and Germany respectively (http://www.statista.com/statistics/268338/daily-per-capita-water-consumption-in-selected-countries-2010/ (accessed 9 July 2014)).

for a large percentage of the water used[9], particularly in small communities. Two water safety plans specifically note the need to manage non-residential demand. In both instances this particular measure is in response to impending short-term or emergency water shortage situations. One plan notes that the water supplier has come to an agreement for shutdown of the industrial operation should this be required. Industrial shut-down is unsustainable and is more likely to address water shortages arising from a mains burst or similar event. Reduced industrial water consumption, rather than shut-down, may be achieved during a drought.

The term "water conservation" is used in several water safety plans[10]. The context is usually in response to a period of water scarcity. This suggests that at least some actions are short-term and likely to include water restrictions. Water safety plans are insufficiently detailed to understand what other measures are included within water conservation. Beyond water restrictions, there is a group of water conservation measures aimed at on-going reduction in water use. This group includes, but is not limited to, such measures as the use of low water-use washing machines, low flush-volume toilets, low flow fixtures, grey-water re-use and rain water harvesting. These measures are voluntary and to be most effective should be undertaken by the community as a whole. Some of these measures, such as grey-water re-use, have the potential to increase public health risks unless properly implemented and managed. Water safety plans provide little information about how these measures might be implemented. Education is noted in one water safety plan. Subsidies are also a possibility, although not recorded in any of surveyed water safety plans. Further detail about implementation may be contained in external documents, such as water demand plans.

The other important category of measures for managing water demand, which is widely noted in water safety plans, is water loss management. This measure reduces unnecessary water consumption arising from leaks. Water loss through leakage may constitute a relatively large percentage of the water demand in a water supply (10-32%, LeChevallier et al undated). Management of water loss includes investigation to identify where losses are occurring and how best these losses might be reduced. Water loss management will contribute to the long-term management of water shortage.

There are limitations to the extent to which on-going water conservation measures and loss management measures allow water shortage to be avoided. For many communities the continuing increase in water demand will eventually outstrip the savings in water use made through water conservation. Then water conservation measures will have to be augmented by measures to increase water availability if the risk of water shortage is to be managed satisfactorily. Despite this limitation, water conservation measures can delay the need for more expensive measures for addressing water availability, such as the development of a new source. A delay allows the territorial authority more time to plan and budget for the larger projects.

[9] Watercare's *Asset Management Plan For the period: 1 July 2012 to 30 June 2022 (*Watercare 2011), states that 61 percent of demand is residential and 26 per cent, industrial, agricultural and commercial.

[10] A distinction is sometimes made between "water conservation" and "water efficiency" with conservation focusing on restricting water use and efficiency reducing water wastage. As none of the 20 water safety plans surveyed use the term "efficiency", in this report, water restrictions is noted as a separate measure and other actions to reduce water usage and waste are covered by the term conservation.

A community's circumstances will determine how long water conservation measures delay the need for additional action. Communities in which population increase is projected to be small, or for which drought severity is not expected to increase greatly, may manage the risk of water shortage for the medium- to long-term on the basis of these measures (and water restrictions) alone.

3.3.3 Qualitative risk evaluation

For each event[11] that a water safety plan records and aims to manage, the water supplier makes a qualitative or semi-quantitative evaluation of the level of risk it presents. The level of risk is determined as the product of likelihood (of the event) and consequence (to public health should the event occur). These estimations of risk help in prioritising supply improvements to manage public health risk, although this risk may not be the only factor taken into account in prioritising improvements.

Two types of risk can be evaluated. The first is the risk **in the absence** of any preventive measures. The second, the 'residual risk'; is the level of risk which takes account of **mitigation by the existing preventive measures**. Some water safety plans give both levels of risk. Others state the 'risk', leaving it unclear which type of risk has been determined.

For prioritising improvements, the 'residual risk' is the risk that should be considered. For the purposes of this report, and understanding the level of risk associated with water shortage, either risk type could be considered, although comparison between water safety plans is invalid unless the types of risk considered are the same. The table in Appendix 1 records the level of risk stated in the water safety plan. Where both levels are given in the plan, the level of risk in the absence of preventive measures is recorded. If only the residual risk is recorded in the water safety plan this is listed in the table and the fact that it is the 'residual risk" is noted.

Most of the water safety plans, as well as recording the level of risk, record the estimates of likelihood and consequence from which the risk value is derived. Differences in the criteria defining the qualitative scales, and differences in the way the panel assessing the risk reached their values for likelihood and consequence, do not allow a direct comparison of the assigned levels likelihood, consequence and risk values between water safety plans.

Scrutiny of the likelihood and consequence values can yield some interesting information about the circumstances affecting a water supply. For example, Supply K notes the loss of resource consent as being "possible" ("Once in 10 years" is the descriptor) and the consequence as "major". It is concerning that loss of a consent to take water for a **large** public supply, or even capping or reduction in the take to the point of threatening adequate availability of water, is considered possible. Further, it is surprising that the consequences are only regarded as "major". The scale used in this plan also has a "catastrophic" level with a descriptor of "Major public health impact". A restriction that limits the ability to supply water to a large population might be considered closer to "catastrophic" given its descriptor.

[11] Defined in the *How to Prepare and Develop Public health Risk Management Plans for Drinking-Water Supplies* (MoH 2001) as "an incident or situation that may introduce a hazard (or hazards) into the water". Although the term hazard is limited in this publication to microbiological or chemical determinands, it needs to be broadened to include water shortage.

3.4 Sources of information

3.4.1 Introduction

The project brief for this study requires the report to assess the sources of information used to prepare the water safety plan. The purpose is to understand which sources of information others may find helpful in assessing and managing the risk of water shortage to their supply.

3.4.2 Documents and databases

Table 5 lists the generic information sources explicitly recorded in water safety plans as being used in the plan's preparation. The documents contained in the table have a range of relationships with the water safety plans.

Some of these documents will have been of generic help in preparing the water safety plans, rather than being of direct help in identifying and managing the risk of water shortage. For example the *Drinking-water Standards for New Zealan*d and WINZ are unlikely to have been of generic help.

Asset management plans, annual plans and long-term plans are identified, in most water safety plans, as being linked to water safety plans. The water safety plan for Supply T explains that there are links between the water safety plan and the water supply's asset management plan and territorial authority's long-term plan. It is probable that the same relationships also apply to the other water safety plans, although this is not made clear in most plans.

Long-term plans provide water safety planning with the required community outcomes needed with regard to water supply, and also information from demographic projections that will influence trends in water demand in the future. Guided by this information, the water safety plan's improvement schedule identifies and prioritises what improvements are needed to achieve the outcomes, given expected changes in water demand. The improvements are implemented through the water supply's asset management plan and the territorial authority's annual plan.

Very little mention is made in water safety plans of the results of climate or demographic projections that were used as the basis for planning. This may relate to how far into the future water suppliers expect their water safety plans to manage the risk of water shortage. This is discussed in Section 4.2.

There is evidence in some water safety plans (eg, the plan for Supply L, mentions development to provide capacity out to 50 years) that planning into the more distant future has been considered, even if detail about that is to be found in external documents. To do this both climate and demographic projections are needed.

Estimations of changes in the drought risk as the result of climate change have been undertaken by the National Institute of Water and Atmospheric Research (Mullan et al 2005). The risk of drought is projected to increase throughout this century in the parts of New Zealand that are already drought-prone. In these areas, under one scenario one-in-twenty year droughts are expected to occur four times as often in 2080 as they do now. The report by Mullan et al provides water supplies with some guidance on changes in drought severity and the areas likely to be affected. For some water suppliers, official climate projections may not be necessary. Experience of drought in recent years will be sufficient to ensure it is included in their risk table.

Demographic projections provide the other key piece of information needed for water supply planning. For large centres, the likelihood of increasing population is high enough that the need to plan for it will be self-evident. For smaller, rural communities, the direction and rate of demographic change is less certain. This is evident from differences between Statistics New Zealand projections and the growth anticipated by the authorities themselves (Nokes 2013).

Table 5 Information sources (not supply specific) recorded in water safety plans as being linked to the water safety plan or being used in its preparation – the document source is given in brackets.

Information sources
Long Term Plan (Territorial authority)
Water Asset Management Plan (Territorial authority)
Demand Management Plan (Territorial Authority)
Territorial authority growth forecast (Territorial Authority
District Growth Strategy (Territorial authority)
Water and Sanitary Services Assessment (Territorial Authority)
Annual Plan (Territorial authority)
Activity Management Plan for Water Suppliers (Territorial authority)
How to Prepare and develop Public Health Risk Management Plans for Drinking-Water Supplies (Ministry of Health)
Public Health Risk Management Plan Guides – various (Ministry of Health)
Regional Plans (Regional Council)
Water management strategies (Regional Council)
Natural Resources Regional Plan (Regional Council)
National Policy Statement on Fresh Water Management (New Zealand Government)
A Fresh Start to Fresh Water (New Zealand Government)
Drinking-water Standards for New Zealand 2005 (Revised 2008), (Ministry of Health)
Draft Guidelines for Drinking Water Quality Management for New Zealand 2005, (Ministry of Health)
Water Information New Zealand (Ministry of Health's water information management system)
Register of Community Drinking-Water Supplies in New Zealand (Ministry of Health)
Public Health Water Supply Grading (Ministry of Health)
Resource Management Act Phase 2 Provisions
Australian and New Zealand Standard AS/NZS 4360:2004

3.4.3 Other information sources

In addition to identifiable documents, water safety plans contain reference to other types of information that is collected, or is planned for collection, to guide planning with respect to water shortage. These measurements, observations and analyses are recorded as preventive measures or corrective actions, or in the contingency plan or the improvement schedule. They are listed in Table 6. Water suppliers developing their first water safety plan, or revising their existing plan, may find the information the table helpful.

Table 6 Measurements, observations and analyses recorded in water safety plans potentially helpful in planning water shortage management

Nature of the information
Management of water demand
Long-term monitoring of water usage, including the hours of use
Leak detection, investigation, monitoring
Behaviour of the network through collection of metering data
Assessment of storage
Flows from reservoirs and periods when capacity is insufficient to meet demand
Management of unavailability of water
Studies of resource and demand management
Investigations of options for new water sources
Monitoring of abstraction rates or levels of surface and well-waters
Storage capacity evaluation
General
Experience from pervious dry periods
Analysis of current and future water demand

3.5 The roles of contingency plans and improvement schedules

3.5.1 Introduction

The foundation of a water safety plan is its risk table. The risk table provides the basis from which the two components of the plan, which are action orientated, are developed. These are the contingency plan and the improvement schedule. This section discusses the purposes of these two plan components, and how they contribute (or should contribute) to the management of water shortage.

3.5.2 Contingency plans

3.5.2.1 The purpose of contingency plans

The Ministry of Health's guide *How to prepare and develop Public Health Risk Management Plans for Drinking-water Supplies* (MoH 2001) states that the purpose of contingency plans is "to provide guidance when hazards have entered the water distribution system, and the actions to take to protect public health should this happen." This view of contingency plans shows a focus on water quality rather than quantity. Since this early thinking on how risks to water supplies should be managed, the view of the purpose of contingency plans has broadened. Contingency plans examined for this study have addressed the need to manage events that include earthquakes, floods, power failures and drought.

Given this extended view of the function of contingency plans it is better to regard them as providing the water supplier with guidance for action when an extraordinary event occurs or when the steps routinely taken to manage risk are overwhelmed. In both situations, a threat to public health may be created because of the quality or quantity of the water.

3.5.2.2 Managing water shortage through contingency plans

Of the extraordinary events for which contingency plans may be needed the majority require a rapid response. These include events such as earthquake, volcanic eruption, and flood. For the contingency plans to be of practical value under these circumstances, the detailed actions required need to have been thought through in advance. This detail should be included in the contingency plan, or another document to which it refers. With insufficient detail, implementing a plan written at a high level under urgency can lead to the event being poorer managed.

Where the contingency plan is designed to manage drought, this particular threat to a water supply is evident well in advance. As a result, the water supplier has time to work through the detail of how the problem will be addressed. Although the urgency of response does not exist, forward planning is still essential. The key problem the water supplier faces when dealing with drought is not knowing how long the drought will last and consequently when, or if, response should be escalated. Having clear criteria already identified for implementing the necessary response stages will help in managing the risk of water shortage.

Although both drought and increasing demand are slow onset threats to a water supply, a contingency plan is only appropriate for addressing the possibility of short-term water shortage. A drought will last for a finite, albeit testing, period. The contingency plan is designed to ensure that the served community has an adequate and safe supply of water during this period.

A contingency plan is unsuitable for managing the risk arising from an on-going increased demand, whether due to population growth or greater industrial or agricultural demand. Should droughts increase markedly in frequency and duration, because of climate change, managing this risk through contingency plans may also become inappropriate and planning for a more robust water source will be needed.

3.5.3 Improvement schedules

3.5.3.1 The purpose of improvement schedules

Section 69Z(2)(v) of the Act requires water safety plans to contain a timetable for the implementation of measures to address public health risks associated with the water supply. In the Ministry of Health's guidance publication on preparing water safety plans (MoH, 2001) this timetable is referred to as an improvement schedule. Its purpose is to ensure that the water supplier is aware of risks that are not being adequately managed by existing measures and that a timetable to address these risks has been established.

The improvement schedule provides the water supplier with some of the information needed in developing their asset management plan. Consequently, the asset management plan is referenced in some water safety plans.

3.5.3.2 Managing water shortage through improvement schedules

The measures contained in water safety plans range in size and cost from such things as optimising the chlorine dose control to treatment plant upgrades. With respect to water shortage, improvement schedules can encompass measures for managing water shortage arising from both short duration events and long-term trends, unlike contingency plans, which are focused on short duration events.

The improvement schedule, through asset management plans and local authority long-term plans (where appropriate), provides a tool by which water suppliers can target long-term effects resulting from such things as climate change and demographic changes. The measures identified in the improvement schedule may be timetabled over a period of several years, but with the intention that the mitigating measures will have an effect over a much longer timescale.

Some water safety plans make relatively brief mention of required improvements. The details may be contained in other planning documents (see discussion in Section 3.4.2).

4 ASSESSMENT OF WATER SHORTAGE MANAGEMENT BY WATER SAFETY PLANS

4.1 Introduction

Section 3 has discussed the information in the water safety plans that relates to managing the risk of water shortage. This section assesses what the information from water safety plans means for the management of risk presented by increased water demand and decreased water availability.

It does this by asking three questions:

a. What situations causing water shortage should water safety plans be expected to manage?

b. What is required for managing water shortage?

c. Is water shortage being adequately managed?

This section identifies generic requirements for managing of water shortage. This information can then be used as a yardstick against which the adequacy of the surveyed water safety plans can be judged, and the adequacy of other plans should this be required. It also provides a guide for developing water safety plans that have yet to be prepared.

4.2 What situations causing water shortage should water safety plans be expected to manage?

The purpose of water safety plans is to manage the risk to public health that may be associated with a community's water supply. A shortage of water to a community presents a potential hazard to public health. It follows that such an event, its possible causes, and the measures that can reduce the likelihood of the event must be identified in the water safety plan.

What is not so clear is the timeframe over which a water safety plan should aim to manage risks. For them to be useful they certainly have to manage existing risks. However, there is no statement in any guidance documentation as to how far water safety plans should look into the future. This is at the discretion of the water supplier[12].

Risk tables include risks that are currently evident and those that may occur at any time, such as the exhaustion of the chlorine supply. The measures used to manage the risk of the chlorine supply running out, for example, are likely to be as satisfactory a decade in the future as they are today.

The situation is different for water shortage. Two major drivers (climate and demographic change) are known that will affect both water availability and water demand, and increase the risk of water shortage in coming decades. The improvement schedule is the component of a water safety plan designed to plan for work needed to adequately manage future risks to a supply.

Examination of the water safety plans in this study shows that improvement schedules list measures to be taken in the near-future, generally, within two to four

[12] Clause 34 of the Local Government Act 2002 Amendment Bill (No.3) requires long-term plans to contain an infrastructure strategy over at least 30 consecutive financial years.

years of the date of approval of the plan. In one instance the implementation period is given as10 years. Improvement schedules also include on-going measures, such as the continuing need to apply for resource consents, without limiting the period over which this is done.

The relatively limited timeframe over which water safety plans list improvements is understandable. Water suppliers are likely to be reluctant to seek major funds to address water shortage that **may** develop in the future, until there is a high certainty that projections will be correct. For large cities, for which water demand is almost certain to increase, planning for measures to manage increased demand may be underway. For rural centres in which trends in demand are unclear, there may be insufficient certainty to invest in capital works, and focus is still on the use of measures to manage short-term risk, which are easily and cheaply implemented. Water safety plans have to be reviewed every five years, at least, and this too may have a bearing on the planning horizon of the plans.

There is a difference between the date of implementation of measures identified in the improvement schedule and the timeframe over which their benefits may arise. The development of a new source in the next year or so, for example, may ensure that the demand for water can be met over several decades. With the exception of one water safety plan (that for Supply L), none of the studied water safety plans indicate how far into the future the benefits of measures to address water shortage are expected to reach. Supply L states that the development of a new source is expected to avoid the need for water restrictions for the next 50 years.

Water asset management plans and territorial authority long term plans are identified in water safety plans as being the documents in which planning to handle more distant risks is to be found.

In summary, the evidence from the evidence of this study is that water safety plans record how existing or near-future risks of water shortage are addressed. They may identify measures to be taken in the near future that will help manage that risk into the more-distant future. However, it is other planning documents with longer time horizons, such as asset management plans and long term plans, that need to be reviewed to understand how well risks from long-term trends in water demand and water availability are being addressed.

4.3 What is required for managing water shortage?

Section 4.2 has concluded that water safety plans are expected to manage the present risk of water shortage. This section discusses what is required to manage the present, and near-future, risk of water shortage, so that the question in Section 4.4 can be answered.

Returning to Table 2 shows the situations in which water safety plans need to be able to manage water shortage. The drought and existing demand situations are of interest here. Water shortage due to emergencies is outside the interest of this study, and the more-distant situation arising from demographic and climatic changes, is managed by other planning documents.

Any of the measures in Table 4 will contribute to reducing the likelihood of short-term water shortage arising from drought. Provided droughts do not occur regularly and for extended periods, the use of short-term measures to manage demand for this

duration may be adequate. Regularly recurring droughts, which may become more frequent, are likely to require a water supplier to develop new sources to make enough water available.

Relatively few of the measures listed in Table 4 will help in managing on-going demand. It is helpful at this point to distinguish between two types of measure that can contribute to managing on-going routine demand. The first are what this report terms **limited measures**. These include loss management, and on-going water conservation measures (ie, not water restrictions). They have an on-going beneficial effect by reducing the demand for water, but their ability to match increasing demand will be limited. They are valuable first steps to take as they will still achieve a reduction in the demand, and allow time to budget more expensive measures.

The second type of measure is termed a **robust measure** in this report. These provide benefit beyond the lifetime of the limited measures. The development of a new source is the most important member of this group. It will increase the volume of water available to a supply. The period for which this increase will be adequate will depend on the rate of increase in demand, and the increase in the daily volume that can be abstracted from the source.

There are other measures that could be considered robust because of their continuing effect. Actions to ensure resource consents allow adequate abstraction of water are an example. In some respects they go hand-in-hand with the development of a new source. A new source is of limited value if a consent to draw adequate volumes of water is not also obtained.

Pre-treatment storage, on a large enough scale, could also be considered a robust measure. Its degree of robustness will depend on circumstances. A pre-treatment reservoir provides a means of smoothing out fluctuations in water availability, but may be limited in its ability to meet a continually growing demand for water.

Water safety plans do not necessarily require all of the generic actions recorded in Table 4 to ensure that water shortage is being adequately managed. However, in judging whether water shortage is being adequately managed the different situations listed in Table 2 need to be considered and whether the measures contained in the water safety plan address these situations.

For some supplies, factors that have been considered important in influencing the demand for water, and therefore the necessary management measures, do not apply. There are some water supplies for which there is no evidence of increasing long-term demand, and in fact, a decrease in households needing to be supplied may be more likely (Nokes 2013). Also, the present study finds that there are some supplies for which the source is practically “unlimited” (large lake with snow-fed inputs). For supplies in this situation, water shortage arising from meteorological or demographic factors need not be a concern, although restricted capacity to treat or deliver water may lead to water shortage.

4.4 Is water shortage being adequately managed?

Section 4.2 concludes that it is reasonable to expect water safety plans to contain measures for managing short-term water shortage. They can also be expected to contain measures to manage on-going water demand, but the period into the future that this risk is managed depends on the water safety plan. For most supplies,

planning for water shortage in the more distant future appears to be considered a responsibility of external documents, such as long-term plans and asset management plans, and therefore is outside the scope of this report.

This section determines what can be concluded about the adequacy of water shortage management by water safety plans, but there are at least three factors that limit the usefulness of these findings.

a. Sample size

   The *Annual Report on Drinking-water Quality 2012–2013* (MoH 2014) states that by the 2012-2013 year, a total of 405 zones had approved water safety plans. The 20 water safety plans reviewed in this study constitute a small percentage of the total. While comment can be made on how well the surveyed water safety plans are managing water shortage, how representative the finding will be for the remaining water safety plans is unknown.

b. Selection bias

   Supplies known to be challenged by drought or increasing demand because of population growth were targeted for selection in the study. As these supplies are possibly more aware of needing to manage water shortage, their water safety plans may not be representative of how well other water safety plans from supplies throughout the country are managing water shortage.

c. Auxiliary documents.

   The project brief for this study intentionally restricted the documents for consideration to water safety plans. Many water safety plans refer to other documents that may contain information key to accurately understanding how adequately the risk of water shortage is being managed. The level of detail in most of the surveyed water safety plan allows measures that in principle should contribute to managing water shortage to be identified. However, greater detail regarding their implementation is needed to be able to determine the adequacy of risk management. For example, the statement “Manage demand” indicates that intention is correct, but provides no information about what the measure entails. Drinking-water assessors, when they undertake their implementation assessment of water safety plans, will be better place to assess the adequacy of the planning detail.

Given these restrictions, the approach in this study to assessing the adequacy of water shortage management by water safety plans is to identify what generic measures could be expected to manage the risk and then determine whether the water safety plans contain these measures.

The discussion is split into two sections discussing short-term risk and the routine risk of water shortage. Both sections discuss the contents of Table 7.

Table 7 presents information from Table 3, but views it differently. The table broadly categorises the measures contained in Table 3 with respect to which type of water shortage the measures aim to manage: short term or on-going routine demand.

Within the routine classification, distinction is made between limited and robust measures (see Section 4.3). In all categories, whether the measure is presently implemented or planned for future implementation is denoted by a “(P)” or “(F)” respectively.

The two right-hand columns of the table provide a pictorial representation of the likelihood and risk levels assigned to drought by water suppliers in their water safety plans. As the criteria for assigning likelihood values are plan-dependent, use of the descriptors (low, medium etc) for comparison purposes is unhelpful. For risk, there are also some plans that have scales with four levels, rather than the usual five. To avoid confusion because of these differences, red stars are used in Table 7 to denote the level of likelihood or risk. Grey stars are added to the red stars to make up the total number of levels in the scale used by the water supplier.

Table 7 Categorisiation of measures to manage short-term and routine water shortage, whether they have been implemented, or are planned, and the assigned levels of likelihood and risk of drought for each supply.

P = presently implemented; F = future implementation noted

Supply	Management of short term shortage (drought)	Management of routine on-going shortage (increased demand and/or high frequency drought)		Likelihood and risk of drought assigned in water safety plans	
		Limited measures	Robust measures	Likelihood	Risk
A	P	F	–	★★★★★	★★★★★
B	P	P	P	★★★★★	★★★★★
C	P	–	P		
D	P	P	F	★★★★★	★★★★★
E	P	P	–	★★★★★	★★★★★
F	P	P	P, F	★★★★★	★★★★
G	P, F	–	F	★★★★★	★★★★
H[1]	P, F	P	–	★★★★★	★★★★★
I	P	P, F	F	★★★★★	★★★★★
J	P, F	P	F	★★★★★	★★★★★
K	P, F	P, F	–	★★★★★	★★★★★
L	P	F	P, F	★★★★★	★★★★
M	F	P, F	P, F	★★★★★	★★★★★
N	P	P	F	★★★★★	★★★★
O	P	F	P	★★★★★	★★★★★
P	P	P, F	F	★★★★★	★★★★★
Q	P, F	P	–	★★★★★	★★★★★
R	P, F	P, F	F		★★★½[2]
S	P	P	–	★★★★★	★★★★★
T	P, F	P	P, F	★★★★½	★★★★★

[1] The likelihood and risk are residual

[2] Pink star indicates 3.5 stars

4.4.1 Short-term risk of water shortage

Table 7 shows that the great majority of the 20 supplies score the likelihood of drought at the mid-level of their scale, or lower. Similarly, there are only three plans in which the risk arising from drought is at a level more than the mid-level of the scale. On this basis, one might expect the management of drought to be generally unsatisfactory, because it is considered relatively unimportant. However, this is not evident from Table 7. The table shows that of the 20 water safety plans reviewed, 19 presently have measures in place to manage short-term threats of water shortage through drought, and the remaining plan records future measures that could be taken to manage this risk.

A possible explanation for this observation is that some likelihood scores do not relate to drought, but to the likelihood of there being a shortage of water for abstraction. If this is reported as the likelihood after mitigations are in place, the likelihood value will be lower than the likelihood of the drought itself.

Summary

On the basis of the information available from the water safety plans, a high percentage of water supplies have measures in place to manage the risk of water shortage arising during drought. Many of these also have limited measures in place for managing routine water shortage, which should further help in reducing the likelihood of problems arising during drought.

The probability of experiencing droughts more severe than those experienced to date increases with time because of the effects of climate change. Such events will test the ability of water restrictions (a common measure to avoid water shortage during drought) to cope, and may demonstrate the need for more robust measures for managing during these conditions.

4.4.2 The risk of routine water shortage

The risk of water shortage arising from routine demand, which gradually stretches the raw water resources of a supply, appear not be as well managed as short-term risk.

Only seven water supplies presently have robust measures in place for managing the routine demand. The water supplier in these cases considers the capacity of their existing source(s), perhaps in combination with other measures, sufficient to routinely meet demand. It is almost certain that Supply S also has such measures in place, but they are not evident from the information received. Five of the seven supplies also have measures in place for managing drought.

There is an additional seven water safety plans identifying the investigation or development of new or alternate sources in future. Planning for new sources is also recorded in four of the seven water safety plans in which robust measures are already in place. This implies that these water suppliers have determined that although present source capacity is adequate, it will not be in the future. This may show that demand projections are being used to guide their planning.

Fifteen water safety plans show that limited measures are in place, and a further three have identified limited measures for future implementation. Ten supplies have limited measures in place, but no robust measures presently. These suppliers may

judge that limited measures are satisfactory for the foreseeable future given the anticipated increase in demand. The information available from the water safety plans is insufficient for determining whether this is the case.

Apart from the two plans in which there is evidence of demand projections having been taken into account (supplies L and T), it is impossible to estimate the timeframe over which water safety plans generally aim to manage water demand. This is because documents external to water safety plans, such as asset management plans and territorial authority long term plans, contain the longer term planning.

The supplies at greatest risk of routine water shortage are those without any presently implemented management measures, that is, those without “P” in either of the routine on-going shortage columns in Table 7. There are two of these.

Summary

As far as can be determined from the water safety plans, approximately one third of supplies have measures in place that are expected necessary to manage the routine risk of water shortage. However, three quarters of supplies, have taken steps to manage the risk through limited measures. These might be satisfactory for the time being for the circumstances of the supply.

These statistics suggest that the risk of routine water shortage is not **presently** being well managed according to the assessment methodology used here. However, most of the surveyed water safety plans show that the risk is recognised and that it is either being managed or there are plans to improve its management.

The partial water safety plan information obtained from some water supplies means that these supplies may be managing the risk better than is indicated by the information to hand.

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5 MATTERS FOR CONSIDERATION

5.1 Introduction

This section is a miscellany of questions and observations prompted by the preparation of this report. They are tangential to the report's purpose, but may inform training or information needs, and so are recorded here.

The topics deal with difficulties or concerns that drinking-water assessors and water suppliers may have with regard to their roles in managing the risk of water shortage.

5.2 The role of the Ministry's guidance tools in influencing the content of water safety plans.

The water safety plan development tools published by the Ministry in 2001 have an emphasis on water quality. This does not imply that the Ministry believes that supply continuity is less important than water quality. Indeed, while the microbiological quality of a water supply is highly important, the public health consequences of a lack of supply are likely to be more severe than a microbiologically contaminated supply.

The emphasis is more a reflection of these documents being the first (and world-leading, at that time) attempt at guiding the use of risk-based methodology in managing water supplies. A chance to correct this imbalance will come when they are next revised.

There are two possible unintentional consequences of the emphasis

a. Water suppliers, or their consultants, may mirror this emphasis in their water safety plans. The limited detail on measures to manage water shortage in water safety plans, or the shift of the detail into external documents may arise in part from guidance documents touching relatively lightly on supply continuity.

   Water suppliers are aware of the importance of supply continuity. Supplier T when discussing the availability of their water safety plan said that their new water safety plan, which was being submitted for approval, was likely to be of more interest to the study than the existing plan because it paid more attention to the management of water shortage. Where water shortage is not presently well addressed in water safety plans this shortcoming may be addressed in the next revision of the plan.

b. Drinking-water assessors may pay relatively little attention to those aspects of water safety plans that aim to manage supply continuity or water shortage. Training courses provide the opportunity for addressing this possible imbalance.

5.3 Reference to external documents

Reference to existing external documents is made in many of the water safety plans surveyed. Section 5.2 has noted a possible factor contributing to this, but a more important influence is likely to be the way the water supplier views the role of their water safety plan, in particular, the extent to which the water safety plan needs to be an operational document.

All the water safety plans surveyed for this study were obtained from territorial authority water suppliers. For these suppliers, especially when preparing water safety plans for large supplies, it may be impracticable to make water safety plans operational documents. Instead, the water safety plan becomes a document for demonstrating compliance with legislative requirements: a relatively high level document acting as a hub connected to external documents which contain the operational detail.

Water safety plans for small, privately operated supplies may be structured differently from the plans of territorial authority supplies. A private supplier is less likely to have the resources, or the inclination, to extend their water safety plan through external documents. These water safety plans may come closer to being operational documents. If this is so, supply size and ownership are factors determining how self-contained and operationally orientated water safety plans are.

Complications arise for drinking-water assessors when the water safety plan refers to external documents. If the adequacy of a water safety plan depends on the external documents to which the plan refers, is the drinking-water assessor obligated to assess these documents as well? If these documents refer to other external documents, do these also have to be assessed?

A drinking-water assessor's audit trail cannot afford to be long. The Act limits to 20 days the time the assessor has for deciding whether to approve the water safety plan. Drinking-water assessors, as a group, may need to debate assessing external documents (if they have not already done so), to reach an agreed approach.

Guidance on how external documents should be used in conjunction with water safety plans, in particular, how water safety plans can show that referenced external documents are adequately managing risk, may help both the water suppler and the drinking-water assessor.

5.4 The relevant timeframe for water safety plans

Several times throughout the report, the question has arisen of how far into the future water safety plans should be aiming to manage public health risk?

The Ministry's guidance documents are silent on the timeframe that water safety plans need to consider. With demographic and climatic projections identifying the risk of future water shortage, there is need to understand the timeframe over which water safety plans should operate. Water suppliers need to know what the temporal scope of their plans should be, as do drinking-water assessors if they are to be able to assess the adequacy of the plan.

Addressing this topic is outside the ambit of the study, but water suppliers and drinking-water assessors will need guidance on what water safety plans should encompass.

6 CONCLUSION

The purpose of this study was to assess how well water safety plans manage the risk of water shortage, created by the two drivers of low water availability and increasing demand.

The relatively small number of water safety plans examined (20), the selection criteria for the participating supplies, and restricting the study to considering only water safety plans, limit the confidence with which the conclusions from the report can be extrapolated to water safety plans in general throughout New Zealand.

Subject to this caveat, the study's conclusions based on the evidence available from the water safety plans are:

a. Water safety plans are the appropriate document for setting out how to prepare for and manage the risk of water shortage from brief emergency situations, drought and existing routine water demand

b. In general, documents external to water safety plans and having a more distant planning horizon, such as asset management plans, and territorial authority long-term plans, appear to be used for future water demand planning, not water safety plans

c. Almost all water supplies presently have implemented measures capable of managing the risk of water shortage arising from drought

d. Only about a third of water supplies have measures in place that are expected to robustly manage the risk of water shortage arising from routine water demand

e. Three quarters of the water supplies have measures in place that although less robust will still contribute to managing the routine risk of water shortage.

As a general observation, although water availability is widely identified as a possible reason for water shortage, increasing demand for water, the second of the two drivers, is much less frequently identified as the possible cause of water shortage.

Three issues became apparent through the study:

a. The Ministry of Health's guidance documents for water safety plan preparation have an emphasis on water quality, which may influence the extent to which continuity of supply is addressed in water safety plans

b. Water suppliers and drinking-water assessors would probably benefit from guidance on how external documents should be used in conjunction with water safety plans, in particular, how water safety plans can show that referenced external documents are adequately managing risk

c. There is presently no guidance on how far into the future, water safety plans should aim to identify and manage risk, and this guidance would be helpful in agree what water safety plans should contain.

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APPENDICES

APPENDIX 1 Water Safety Plan contents relating to water shortage arising from increased demand or reduced water availability

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: A		Supply Class: large	Source: river; bores		
Event: Not enough river water available for abstraction					
	Causes: Drought and resource consent limitations		Risk: Extreme (possible x catastrophic)		
		• Water conservation measures • Long-term monitoring of usage	• Supplement with bore water	• Restrict water use • Implement emergency demand management strategy. • Switch to an alternative source of water until adequate water of acceptable quality can again be supplied, or use storage. • Close reservoir valves to restrict supply • Use alternative source, if river is too low for abstraction • Find and develop new or supplemental source	• Long-term study of resources and demand management • Change district plan • Construct supply infrastructure • Water-use reduction strategy

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: B	Supply Class: large	Source: rivers (x2); dams (x2)			
Event: Drought affecting River 1 and both dams					
	Causes: Reduced rainfall resulting in low water level in dams	Risk: Medium (possible x major)			
		• Dam levels monitored weekly • Water restrictions imposed if required. • Augment supply from second treatment plant		• Restrict water use • Start second treatment plant	• None relevant stated
Event: Drought affecting River 2					
	Causes: Reduced rainfall or increased upstream water	Risk: Medium (possible x major)			
		• Liaise with District water Conservators (Consenting Authority) and impose restrictions on other uses if required • Monitor extent of abstraction or number of consents • Use water from first treatment plant		• Restrict water use • Liaise with District Water Conservators	• None relevant stated

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: C	Supply Class: large	Source: river (x2) – direct abstraction and infiltration gallery			
Event: No water available					
	Causes: Natural disaster – earthquake flood		Risk: Moderate (rare x catastrophic)		
		• Civil defence • “Lifelines”	• Provide water by tanker		• Develop lifelines further
Event: Treated storage fails					
	Causes: Raw and treated failure from a major event such as earthquake		Risk: Moderate (rare x catastrophic)		
		• Civil defence • “Lifelines”	• Provide water by tanker		• Develop lifelines further
Event: No water available from one source					
	Causes: Water not available from one of the sources		Risk: Low (unlikely x minor)		
		• Dual sources	• Manage demand • Switch to other source		

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: D	Supply Class: minor	Source: river			
Event: Loss of supply					
	Causes: Inadequate water in the river		Risk: Very high (unusual x extreme)		
		• Agreement with freezing works to shut down during supply problems			• Identify secondary sources to back up primary source
	Causes: Drought causing loss of water		Risk: High (unusual x major)		
		• Agreement with freezing works to shut down during supply problems		• Implement demand management strategies as required. • Advise customers to conserve water. • Shutdown freezing works. • Identify alternative water sources • Be prepared to use an alternative supply • Keep customers informed and advise once regular service is restored	• Identify secondary sources to back up primary source
	Causes: Excessive leakage and high demand exceeding scheme capacity		Risk: High (possible x medium)		
		• Agreement with freezing works to shut down during supply problems • More than 24 hour short-term storage • Leak detection undertaken			• Monitor data to assess potential leakages • undertake periodic leakage investigations • install bulk meters to allow better understanding of network

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: E		Supply Class: minor	Source: bore field		
Event: Not enough source water available for abstraction					
	Causes: Resource consent limitations.			Risk: Moderate (unlikely x major)	
		• Abstraction rates for the bores are monitored. • Current consent adequate to satisfy existing requirements and foreseeable requirements. • If required, attempts will be made to negotiate new resource consents or emergency provisions.			
	Causes: Drought			Risk: Moderate (unlikely x major)	
		• Water conservation measures are put in place as soon as water shortage becomes likely			
Event: Not enough water in post-treatment storage to meet demand					
	Causes: Inadequate post-treatment storage capacity.			Risk: Low (unlikely x moderate)	
		• Current capacity is adequate for current and expected future demands. • Water conservation practices are encouraged during periods when demand is likely to be high.		• Implement emergency demand management strategy. • Put conservation measures in place. • If shortages occur frequently because of too little water available at the source, plan for finding and developing a new source.	

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID.: F		Supply Class: minor	Source: river (primary); river (supplementary)		
Event: Loss of supply					
	Causes: Drought, extreme low flow in river.		Risk: High (possible x medium)		
		• 25 days storage provided in pre-treatment storage ponds. • Demand management programme when shortage is possible. • Supplementary supply available.			
	Causes: Insufficient source water available to meet demand over an extended period.		Risk: High (possible x medium)		
		• Demand management can be implemented. • 25 days storage provided in pre-treatment storage ponds. • Supplementary supply available			
	Causes: Insufficient water available for abstraction		Risk: High (possible x major)		
		• Two abstraction points (same stream) *Potential* • Investigate alternative water sources.		• Advise customers to conserve water • Implement demand management strategies as required • Arrange emergency water supply (tankers) if necessary • Keep customers informed and advise once regular service is restored	

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Event: Inadequate water storage (treated)					
	Causes: Reservoir volume inadequate		Risk: High (likely x medium)		
		• Reservoir holds 8 hours of treated water. *Potential* • Manage demand during times of high water use. • Investigate water losses and put in place a programme to reduce loss. • Increase storage capacity of reservoir or construct an additional reservoir to provide 24hours storage.			

Supply ID: G	Supply Class: medium	Source: river (infiltration gallery bores)			
Event: Insufficient water					
	Causes: Extended dry period and water table drops.		Risk: Moderate (unlikely x moderate)		
		• Previous dry periods provided valuable well management experience. • Sources from other communities on the supply can be used in an emergency *Potential* • Formalise well management plan to ensure maximum drawdown levels are not exceeded. • Upgrade well pump controls as required. • Prepare water restriction guidelines • Check that alternative source is saltwater free during normal flow conditions	• Refers to Contingency Plan	• Identify cause and time required to reinstate source • Assess storage and hours of supply available. • If insufficient water available inform DWA. Use radio, and social media site to inform community of water restrictions until the source problem has been resolved. • Consider options for augmenting the water supply – alternative sources linked to the supply and tankered water.	• .Additional storage • Options to reduce water demand

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Event: Gradual loss of supply over several years					
	Causes: Blinding off of wells.		Risk: Moderate (rare x moderate)		
		• Three wells - unlikely all three will blind off at once. • Time to put mitigations in place as the problem will develop gradually. *Potential* • On-going monitoring of well gallery water levels • Eventual replacement of wells when the gallery reaches the end of its economic life • Development of demand management plan – water use presently very high			.
Event: Use of inadequately treated water					
	Causes: Treatment plant output cannot maintain reservoir level		Risk: High (unlikely x major)		
		• Nine hours storage presently available. *Potential* • Preparation water restriction guidelines • Development of hydraulic model to identify needed improvements to existing reservoirs and new reservoir requirements. • Installation of more reservoir capacity as required			.

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: H	Supply Class: large		Source: lake and river		
Event: Insufficient raw water volume					
	Causes: See Guide series		Residual risk: Moderate (rare x major)		
		• Manage allocation by resource consents			.
Event: Insufficient raw water					
	Causes: Drought		Residual risk: Low (unlikely x minor)		
			• Water restriction advertising (reference to external document)		• .Water demand management plan – Incident response plan will be updated to include a section to water demand management decision making.
	Causes: Resource consent limitation		Residual risk: Low (unlikely x minor)		
		• Make submissions on regional fresh water plans • Maintain existing abstraction consents			
Event: Reservoir too low or empty					
	Causes: Insufficient raw water flow into the system		Residual risk: Low (unlikely x minor)		
			• Water restriction advertising (reference to external document)		.

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: I		Supply Class: minor	Source: Well (infiltration gallery)		
Event: Not enough source water available for abstraction					
	Causes: Drought		Risk: Moderate (possible x moderate)		
		• Implement water use restrictions before demand outstrips supply. • On-going renewal of pipes to reduce leakage (and therefore demand). • Regional council management policy. • Completion of a water demand management plan for the supply. • Leakage loss assessments completed 2011 and repairs made.	• Implement next stage of rationing. • Carry out extra leak monitoring to control wastage. • Use other scheme water	*Plan 3* • Decide whether to use an alternative source of water, or to use storage. • Put conservation measures in place. • Close valves at reservoirs to restrict supply if necessary. • Assess capacity of bores individually. • Plan to find and develop a new source, if shortages occur frequently because of water availability. *Plan 8* • Establish reason for the shortage. • If high bulk usage or fire fighting are the reason, establish extent of usage and arrange other source. • Before drinking water runs out consider restricting water use. • If leakage is suspected, carry out a detailed	• Establish new source in a higher yield aquifer. • Carry out more regular leak detection

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
				systematic inspection of the system to establish cause. ○ If repair simple, carry out, if not .carry out a temporary bypass or repair until a permanent repair can be made. ○ Assess the effect on water quality of temporary repair, and action as necessary. • If low yield of bores is the cause, use RMP 3.	
	Causes: Resource consent restrictions		Risk: Moderate (possible x moderate)		
		• As above	• As above	• As above	

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: J	Supply Class: large		Source: Wells (feed from reticulated supply in emergency)		
Event: Not enough water can be drawn from the well to meet demand					
	Causes: • Insufficient source water to meet demand • Fall in groundwater levels (summer). • Aquifers slow to recharge. • Over allocation to other users.		Risk: Extreme (almost certain x major)		
		• Regional Council management policy. • Water use monitoring. • Water use restrictions • Water demand management plan for the supply including leakage loss and water wastage assessments	• Supplement with water from neighbouring supply with spare capacity. • Invoke water restrictions.	• Establish reason for the shortage. • If high bulk usage or fire fighting, establish extent of usage and arrange other source before drinking water runs out • If leakage is suspected establish cause. When leakage is located, repair. • Issue water restriction notices as needed to control demand until problem identified and rectified. • If low groundwater level is the cause, stop pumping and check status of other bores using the same aquifer. Utilise either of two neighbouring bores to supplement. • If structure failure is the reason, inform engineering consultants	• Develop plan to blend with neighbouring supply • Develop new water source.

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
				on possible effects on quantity and quality • If repair simple, carry out, if not .carry out a temporary bypass or repair until a permanent repair can be made. • .Assess effect of any temporary repair on water quality, and action as necessary. • If water shortages occur frequently, consider additional or alternative source.	

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: K		Supply Class: large	Source: river		
Event: Loss of Supply					
	Causes: Drought or extreme low flows in river making intake ineffective			Risk: High (possible x major)	
		• Intake is at sufficient level to cope with known low flow events • Floating intake can be used if required. *Potential* • Investigate alternative/emergency water source	• Shift intake to most appropriate alternative intake • Switch to tankered water supply	• Advise customers to conserve water via press releases to local radio stations and newspapers • Implement demand management strategies as required. • Arrange emergency water supply (tankers) if necessary • Keep customers informed and advise (as above) once regular service is restored • Arrange alternative supply as necessary (tankers).	• Investigate alternative/emergency water supply
	Causes: Over allocation by regional council to other consent holders			Risk: High (unlikely x major)	
		• Existing resource consent *Potential* • Participate in resource allocations discussions/process with regional council • Consider alternative/emergency water source	• Make submission to relevant resource consent applications to prevent over allocation		• Participate in resource allocation discussions/process with regional council
	Causes: Excessive demand in network or inadequate system capacity			Risk: Moderate (possible x medium)	
		• Reservoirs store 24 hours average supply	• Advise public of shortage of supply • Request conservation of water by	•	•

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
		• Reservoirs fill on level control – filling capacity is not compromised by high demand • All areas have at least 15l/min and 20m pressure at point of supply • System meets fire, flow and demand requirements • Check valves incorporated in all meters	consumers or impose restrictions •		
Event: Loss of right to take water					
	Causes: Consent to take is not renewed, or declined, by regional council Risk: Very high (possible x major)				
		• Current consent is valid until 2026 *Potential* • Investigate alternative/emergency water source	• Apply for consent will in advance of consent expiry • Appeal decision	•	•

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: L	Supply Class: large		Source: springs/stream; springs; dam and river		
Event: Insufficient raw water for abstraction					
	Causes: Drought		Risk:		
		• Reduce water take from the sub-area • Switch to alternative source (where available *Potential* • Construction of a new intake from a new river source and associated upgrade of treatment plant that will abstract from it • Reduce unaccountable water loss • Undertake active leak detection and pressure management programme	• Make more use of other sub–area sources within the water supply area • Impose a range of progressively stricter water restrictions		• Develop new river source
	Causes: Resource consent limitations		Risk: Low (possible x insignificant)		
		• As above	• As above		
Event: Not enough water to meet demand					
	Causes: Insufficient raw water flow into the system		Risk: Moderate (rare x moderate)		
		• None stated *Potential* • Medium term develop intake for new river source	• Utilise capacity of other sources and treatment plants feeding into the supply •		
	Causes: Insufficient treatment capacity		Risk: Moderate (rare x moderate)		
		• Treatment capacity designed to meet peak demands, buffered by treated water storage as balance tank	• Water restrictions		

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
		Potential • Further treatment capacity required to meet future growth requirements. Either upgrade existing plant or construct new plant to treat water from new river source (lower quality than the current source). Limitation on capacity linked to future demand and utilisation of new river source. • Water demand management, reduction in unaccountable for water			
	Causes: Insufficient treated water storage		Risk: Moderate (possible x minor)		
		• Maintenance of pumps (pumped systems) *Potential* • Provision of more storage • Stand-by generators (pumped systems)		*Gravity feed* • Water restrictions *Booster pump* • Reactivate booster pumps • Tankered water	• Arrange for tankered water to be provide to zones reliant on pressure boosters • Provide electrical connections for mobile generator • Provide additional storage capacity, where needed

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: M		Supply Class: small	Source: bores		
Event: Loss of supply					
	Causes: Lowering of water table from excessive abstraction		Risk: Low (rare x medium)		
		• Two bores available • Input to resource consents seeking to abstract from the aquifer, asking for a requirement to report on daily abstraction volumes • Low level pump cut out mechanism in place.			
	Causes: Lowering of water table due to extended period of dry weather or drought		Risk: High (unlikely x major)		

		• Two bores available
		• Each property serviced has on-site storage
		Potential
		• Develop a Business continuity Plan / Water demand management Plan (district wide) that includes:
		  • steps to be taken to reduce consumption when demand approaches the maximum consented water take or during water shortage conditions
		  • public and commercial user education programmes. steps to be taken to reduce consumption
		  • enforcement procedures
		  •
				• Advise customers to conserve water
				• Implement demand management strategies as required
				• Arrange emergency water supply (tankers) if necessary
				• Keep customers informed and advise once regular service is restored
					• Develop a water demand management Plan and or Business continuity Plan to address loss of water supply and what steps must be implemented, including:
					  • Alternative supply if necessary,
					  • Steps to be taken to reduce consumption.

	Causes: Failure of bore - cannot be restored in a short time frame and requires re-drilling		Risk: High (likely x medium)		
		Potential			• Investigate alternative

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
		• Establish a new bore or alternative source of drinking water to provide security of water supply.			source (now complete). For security of supply a new bore will be drilled.
	Causes: Consent to take water expires and is not renewed or is declined by regional council Risk: Very high (likely x major)				
		• Consent has already been granted to take water. (to 2045) • Renewal of consent is applied for at least 6 months in advance of existing expiring			• Apply for renewed consent to take water, in advance of existing consent expiring

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: N		Supply Class: large	Source: river		
Event: Insufficient water for abstraction					
	Causes: Drought		Risk: High (unlikely x catastrophic)		

		• Water conservation and demand management plan is in place.
		• Intake channel and low lift wells are kept clean from debris to prevent restricting flow to the pumps.
			• Review management plan.
			• Initiate water use restrictions
				• Contact regional civil defence management group for advice and notification
				• Implement actions of Water intake contingency & Drought management plans
				• Implement drought response of the water demand management plan
				• Assess exact damage to the intake structures if earthquake
				• Consider:
				  ○ Shutting down the plant until faults can be remedied
				  ○ Supplying water directly from Reservoirs
				  ○ Setting up collection points for water supply across the city.
				  ○ Obtaining water from alternative source
				• Notify and work with PHU, regional council and territorial authority
					• Investigate alternative source
					• Formalise a regular programme of cleaning of the intake channel and low lift wells

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
				management	
	Causes: Low river levels		Risk: High (possible x major)		
		• Monitoring of the river level is undertaken. • Water conservation and demand management plan is in place.	• Implement water contingency plan • Review management plan. • Initiate water use restrictions	• As for drought	• Investigate alternative source
Event: Not enough water in post-treatment storage to meet demand					
	Causes: Inadequate post-treatment storage capacity		Risk: Medium (unlikely x major)		
		• Water conservation and demand management plan is in place. • Capacity is known to be able to provide potable water for approximately 24 hours at average daily consumption rate without the plant operating. • Storage capacity is evaluated as part of the LTCCP process and the City Growth Strategy.	• Initiate water restrictions. • Consider increasing storage capacity.	• As for drought	

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: O		Supply Class: large	Source: lake		
Event: Too little water can be drawn from the source to meet demand					
	Causes: Drought depletion occurring.		Risk: Moderate (possible x moderate)		
		• Lake source presents an unlimited water supply not subject to droughts *Potential* • Implement the Water Demand Management Plan to control excessive demands for water in future	• Use reservoir storage in the short term if sufficient. • Provide alternative emergency supply if reservoir is run down. • Invoke emergency water use restrictions for the town under the Water Demand Management Plan and Water Supply By-law. • Invoke water use restrictions under the By-law if supply is interrupted • Actions specified in the WDMP and Water Supply by-law • If Corrective Actions fail, refer to Loss of Water Contingency Plan	• *Contained in diagram in water safety plan*	
	Causes: Resource consent limits reached or exceeded		Risk: Moderate (possible x moderate)		
		• Daily abstraction rates are always within the water take limits *Potential* As for drought	• As for drought		
	Causes: Excessive consumer demand and leakage		Risk: Moderate (possible x moderate)		
		• A comprehensive Water Demand Management Plan has been completed *Potential* As for drought	• As for drought		

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Event: Not enough water in post-treatment storage to meet demand					
	Causes: Inadequate storage capacity exacerbated by high demand and excessive water leakage Risk: High (almost certain x high)				
		• Reservoir low level sonic probes initiate intake pumps and plant start up • Water Demand Management Plan has been drafted and submitted to district council • Reservoirs are generally adequate for the average demands on them • SCADA low reservoir alarms are fitted to warn the operator *Potential* • Fit earthquake (high flow) shut off valves to the remaining reservoirs to ensure at least 50% of stored water volume can be saved. • Implement the Water Demand Management Plan Recommendations and Water Supply by-law to reduce water losses to an acceptable level.	• Issue immediate notice of water restrictions to the community if supply is seriously interrupted for more than 4 hours • Attend to consumer complaints about loss of pressure or supply as per the Operations & Management contract and report to Council • Repair lift and booster pumps using standby capability. • Rely on stored water if possible till service is resumed • If corrective action fails, refer to Shortage of Water Contingency Plan		• Implement the Water Demand Management Plan to control excessive demands for water in future • Investigate the feasibility of either upgrading or decommissioning one of the Intakes • Related to the above, develop the feasibility plan for a single intake from a more pristine part of the lake

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: P	Supply Class: large		Source: stream		
Event: Insufficient raw water					
	Causes: *Not stated*		Risk: Low (possible x moderate)		
		• Do nothing • Monitor levels	• Undertake analysis of current and future demand.		• Investigate additional raw water abstraction from the existing source including the side stream (catchment management practices). • Analyse current and future demand of raw water supply. • Investigate new reservoir option along with potential bore water supply options. • Review the effectiveness of the current water supply demand management needs to cater for the high summer demands. Include a review of rural connections. • Review using active leakage control to minimise system losses.
Event: Insufficient reservoir capacity (reduced water, no water)					
	Causes: *Not stated*		Risk: High (likely x major)		
		• Do nothing • Increase capacity	• Monitor flow from reservoirs and note periods when capacity is insufficient to	• Check operation of pumping stations.	

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
		• Reduce water usage • Carry out active leakage control	meet demand, keep records. • Start water conservation in high use periods. • Review demand management programme for effectiveness. • Plan and implement new reservoir.	• Check bulk supply. • Check outflow from reservoir for unusually high flows. • Check reservoir control system. • Check for reservoir leakage. • Consider possibility of backflows or other contamination of system (including sediment problems) if there has been loss of system pressure. • Identify the reasons for low reservoir level and take steps to avoid repeat. • Reflect system alterations that may be necessary in Water Supply Asset Management Plan.	
Event: No water in reservoirs (large demand in summer months)					
	Causes: *Not stated*		Risk: Low (Unlikely x moderate)		
		• Do nothing • Check main feeds to reservoirs. • Reduce water usage especially large customers. • Check for major leakage or failure or blocked. • Initiate river pump when reservoir levels drop below 70%.	• Monitor flow from reservoirs and note periods where capacity is insufficient to meet demand, keep records. • Start water conservation in high use periods. • Review demand management programme for effectiveness.		

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Event: Not enough water (no water, reduced pressure)					
	Causes: *Not stated*		Risk: Low (possible x moderate)		
		• Do nothing • Monitor demand in reservoirs • Advise large customers to reduce demand • Initiate sprinkler ban • Check for major leaks in network	• Active leakage control	• Check reservoir levels and flows. • Check operation of pumping stations. • Check bulk supply. • Consider possibility of backflows or other contamination of system (including sediment problems). • Warn consumers to thoroughly flush their taps before drawing water for use. • Make arrangements for potable water tankers to reside in the affected areas and supply water to residents. Alternative water sourced is only from registered drinking-water supplies. For the more vulnerable population supply bottled water and arrange for potable water tanks (with pumps if needed) to be installed at properties such as rest homes and hospitals. • Review test results and need for further additional testing (in excess of normal testing programme).	

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
				• Identify the reasons for disruption and take steps to avoid repeat. • Reflect system alterations that may be necessary in Water Supply Asset Management Plan.	

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: Q		Supply Class: neighbourhood	Source: Lake		
Event: Loss of supply					
	Causes: Drought causing lake level to drop below intake		Risk: High (possible x medium)		
		• Intake located 50 metres off shore in 30 metres depth of water • Conditions on resource consents. *Potential* • Investigate connecting neighbouring supply to the reservoirs for use as a backup supply or increasing the storage at this supply.		• Advise customers to conserve water • Implement demand management strategies as required • Arrange emergency water supply (tankers) if necessary • Keep customers informed and advise once regular service is restored	• Investigate connecting neighbouring supply to the reservoirs for use as a backup supply or increasing the storage at this supply.

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: R		Supply Class: large	Source: River		
Event: Drought causing inadequate supply of water					
	Causes: Drought		Risk: Medium high		
		• Develop contingency plan to address supply restrictions in drought which includes: o alternative supply implications o implementation of demand management restrictions at changing trigger levels of supply availability. Differentiate between residential and commercial use	• Implementation of demand restrictions through enforcement of bylaw.	• Implementation of demand management and water restrictions.	• Develop contingency plan for supply restrictions in drought. Differentiate between residential and commercial users.
Event: Not enough water for abstraction					
	Causes: Drought and resource consent limitations		Risk: Low		
		• Ensure integrity of weir is maintained	• Water conservation measure such as stepped hosing restrictions implemented		
Event: Not enough water available to meet demand					
	Causes: Demand exceeds river flow availability		Risk: High		
		• Implementation of hosing restrictions and hose pipe bans and other demand restrictions according to existing implementation plan • Review options with regional council to take more than consent in unusually dry events and also seek information from the regional council about the probability of dry events that would limit the abstraction to less than 28,000m^3/day.	• Review effectiveness of hosing and water use restrictions.		• Review options with regional council to take more than consent in unusually dry events.

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Event: Not enough water (storage reservoir)					
	Causes: Excessive demand		Risk: Low		
		• Total storage is ample.(ca 2.5 days) • Control excessive demand through leak detection and hosing restrictions.	• Implement step hosing restrictions if supply cannot match demand	• Implement supply restrictions	
Event: No water/insufficient water					
	Causes: Excessive use/drought		Risk: Low medium		
		• Impose triggered hosing/outdoor use restrictions with stage level of enforcement • Odds/evens house numbers for garden sprinklers • Hand held hoses at all times • Total hosepipe ban	• Public notices/advertising and imposition of penalties for excessive use of water.		

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: S		Supply Class: large	Source: lakes, river, bores		
Event: Not enough water available for abstraction					
	Causes: Drought		Risk: 9.5/25 (2.3(consequence) x 4.2 (likelihood))		
		• Integrated source management model modelling abstractions weekly • Agreed drought management plan in place • Multiple screens to allow full lake level utilisation • Multiple screens to allow full river level utilisation and to meet maximum abstraction rate at 1:100 year low river level		• Implement drought management plan • Maximise number of intake screens open • Maximum run of river sources	

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
Supply ID: T	Supply Class: large		Source: river/lake		
Event: Insufficient water available for extraction					
	Causes: Drought		Risk: Low (Likely x minor)		
	Causes: Resource consent limitations		Risk: Low (Likely x minor)		
Event: Inadequate flow through reticulation					
	Causes: Inadequate bulk water supply		Risk: Low (Unlikely x moderate)		
		• Forward planning to meet future bulk water demand • Flexibility to supply from alternative sources			
Event: Not enough water in reticulation storage to meet demand					
	Causes: Inadequate bulk water supply		Risk: Low (Unlikely x major)		
		• Forward planning to meet future bulk demand • Flexibility to supply from alternative sources			
	Causes: Inadequate reservoir storage capacity		Risk: Low (Likely x minor)		
		• System capacity designed to meet demand • Modelling of system capacity • Water supply asset management plan incorporates water consumption targets and supporting strategies • Water supply asset management plan identifies service gaps and plans	• Implement contingency plan in event of significant supply disruption • Investigate alternative supply to area affected. • Consider requirement for public notification • Water conservation • Water use restrictions		

		Preventive Measures	Corrective Action	Contingency Plan	Improvement
		for upgrading works to meet demand • Water conservation programmes • Water restrictions during periods when demand is likely to be high	• Construct additional storage		
	Causes: Increased demand due to development exceeds ability of system to supply Risk: (Unlikely x minor)				
		• Demand projections for future water supply in asset management plan • Asset development programme in asset management plan.	• Consider requirement for public notification • Consider water conservation programme until system capacity can be increased • Investigate reasons for higher than predicted consumption • Revise demand projections in asset management plans if necessary, and associated programmes.		

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APPENDIX 2 List of measures for managing drought

Adapted from a table from *Managing Water for Drought* (USACE, 1994))

Supply Alternatives
New storage
Reallocation of supplies
New system interconnections
Desalinization, importation by barge, reuse
Operational Changes
Conjunctive use management
Water banking
Long-term changes in reservoir release rules
Conditional reservoir operation and in-stream flows
Water marketing
Institutional changes
Legal changes
Operational coordination between systems
Demand Modification
Voluntary and mandatory use restrictions
Pricing changes
Public awareness
Changes in plumbing codes
Conservation credits
Changes in irrigation methods
Industrial conservation techniques
Alternatives to water consuming activities
Environmental and Water Quality Changes
Reductions in required low flows
Alternative means of achieving water quality

The reader is referred to the original report (see reference section for URL) for discussion of measures contained in the list above.